NATIONAL BUREAU OF STANDARDS REPORT

6904

Field Tests of Runway Distance Markers
Constructed by NAS Cecil Field

By
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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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ABSTRACT

This report gives the results of tests of the visual range and recognition distance in conditions of restricted visibility of a type of runway distance marker developed and fabricated at the Cecil Field Naval Air Station. The markers are internally illuminated for nighttime use. The performance of these markers at night is much better than that of the externally illuminated markers which were tested previously.

1. INTRODUCTION

The present Navy standard requirements for runway distance markers are given in code 134 90.2, NAVAER 00-100-503[1/] and drawing SE 134 90.2-1, NAVAER 00-100-505[2/]. The results of the field tests of the standard marker are given in National Bureau of Standards Report 5466[3/]. As pointed out in that report, the useful range of these externally illuminated markers at night is less than is desirable and studies of other types of markers which might increase the visual range at night were recommended.

In January 1959 two internally illuminated runway distance markers were received at the Visual Landing Aids Field Laboratory, Arcata, California, for test and evaluation. These markers were designed and constructed at the Cecil Field Naval Air Station. The markers were to be tested in restricted visibility conditions at night and during daytime for comparison with the performance of the standard markers.

2. EQUIPMENT AND INSTALLATION

The Cecil Field runway distance marker (see figure 1) consists of an aluminum housing with plastic panels and is mounted on frangible couplings at three points. Single numeral panels are 36 x 46 inches with a black opaque background and a yellow transparent numeral. The numeral has a stroke width of 4 inches of transparent plastic plus a 3/4-inch-wide border of yellow retroreflective tape. Apparently the border is intended to provide a wider stroke width during daylight in order to increase the effective range.

The marker is an isosceles triangle, with the apex of the triangle pointing toward the runway. The panels make an angle of 83° with the axis of the runway. When the panels are in place, the unit is virtually weathertight and dusttight.

The marker is wired with six medium screw base sockets, three on each edge, which can be positioned at 3-inch intervals starting five inches from the top or bottom of the panel. All sockets are wired in parallel. The lighting arrangement that was recommended by Cecil Field was the use of four 120-volt, 150-watt lamps energized through a 200-watt, 6.6-ampere secondary, series-series transformer with the primary connected to the runway lighting circuit. An alternate suggestion was to use six 100-watt lamps instead of the four 150-watt lamps.

The weight of a unit is 75 pounds.

3. TEST PROCEDURE

One of the Cecil Field runway distance markers was installed at the Arcata Airport on the left side of runway 31, about 2000 feet from the threshold. The axis of the marker was aligned perpendicular to the runway centerline with the near edge of the sign 25 feet from the edge of the runway pavement. The panels used contained the numerals 2 and 4.

Observations were made from a vehicle along the centerline of the 150-foot-wide runway. The panel with the numeral 2 could be observed along a 4000-foot section of runway and the numeral 4 along a 2000-foot section of runway. Visual observations were made and the following information was recorded for each test.

> Detection range. The maximum distance at which the observer could detect the presence of some configuration on the surface of the marker.
>
> Recognition range. The maximum distance at which the numeral was legible with reasonable certainty to the observer.
>
> Conspicuous range. The distance at which the driver of a vehicle traveling at a moderate speed (40-45 mph) could unmistakably read the numeral on the marker at a glance.

The maximum useful range should be between the recognition range and the conspicuous range.

The three visibility ranges defined above were obtained for both daylight and nighttime conditions as a function of the meteorological visibility. The meteorological visibility was obtained by visual observation of dark targets in daytime and of lights at night.

In the tests of visibility ranges at night, four 150-watt, 120-volt lamps positioned 14 inches from the top and bottom of the panel were used for the illumination. The lamps were energized from a multiple circuit at 110-115 volts. The lamps were energized from a multiple circuit in order to reduce the number of variables to be evaluated. In addition, several sets of comparative observations were made with the lamps energized from the runway lighting circuit. For these observations, the lamps were energized through a single 200-watt, 6.6/6.6-ampere, series-series transformer connected to the runway lighting circuit. The runway lights were operated at each of the five intensity settings. A series transformer manufactured by the American Gas Accumulator Company was used in these tests because it is representative of transformers suitable for energizing multiple lamps from series transformers (see NBS Report 6337[4]).

In evaluating the preferred size of lamps and lamp positions for service use, observations were made and the brightness at the center of the panel was measured with the marker illuminated by the following types of lamps, using both four and six lamps:

100-watt, 120-volt lamps
75-watt, 120-volt lamps
type PH/211, 75-watt, 115-volt photo-enlarger lamps
type PH/212, 60-watt, 115-volt, photo-enlarger lamps.

For these observations the lamps were energized by the series transformer from the runway lighting circuit.

4. RESULTS AND DISCUSSION

The average visibility ranges obtained during the daytime tests of the Cecil Field runway distance marker are given in table 1.

Table 1. Daytime performance of Cecil Field runway distance marker.

Visibility (Miles)	Detection Range (Feet)		Recognition Range (Feet)		Conspicuous Range (Feet)	
	Cecil Field	SM*	Cecil Field	SM	Cecil Field	SM
Over 1	2700	(2200)	1800	(1800)	790	(1200)
1/2	1700		1400		700	
3/8		(1800)		(1300)		(1000)
1/4	1400		1150		610	
3/16	930		740		440	
1/8	580	(500)	500	(380)	310	(180)

* Standard marker with International orange background. Tests reported in NBS Report 5466.[3/]

It will be noted that there is very little difference in the detection and recognition visual ranges for the markers. The conspicuous range of the Cecil Field marker is considerably less than that of the international orange marker except at visibilities below one-quarter mile. The lower contrast between the panel of the marker and the background is apparently the reason for the lower conspicuous range. The reason for the increase in conspicuous range when the visibility is one-quarter mile or less is probably the high contrast between the numeral of the marker and the black panel and the increased angular size of the numeral.

The average visibility ranges obtained during the nighttime tests of the Cecil Field runway distance marker are given in table 2. These observations were made when the marker was illuminated by four 150-watt lamps operated at 110-115 volts.

Table 2. Nighttime performance of Cecil Field runway distance marker.

Visibility (Miles)	Detection Range (Feet)		Recognition Range (Feet)		Conspicuous Range (Feet)	
	Cecil Field	SM*	Cecil Field	SM	Cecil Field	SM
Over 1	2500	(1500)	1700	(1300)	820	(880)
1/2	1900		1550		740	
3/8		(1050)		(860)		--
1/4	1350		1100		600	
3/16	1150	(680)	980	(540)	520	(280)

*Standard marker with international orange background. Tests reported in NBS Report 5466.[3/]

It will be noted that the Cecil Field marker provides much better visibility ranges than the standard marker with international orange background. The visibility ranges of the Cecil Field marker for daytime and nighttime are very similar.

During nighttime conditions when the lamps were energized at 110-115 volts, the Cecil Field marker was too bright for visibilities of 1/2 mile or better, but the brightness was satisfactory for visibilities at which the runway lights are normally operated at rated intensity (step 5). When the lamps were energized from the runway lighting circuit through a single series transformer in visibility conditions for which the runway lights are normally operated at 0.2 percent of rated intensity (step 1), the brightness of the marker was considered to be somewhat low with four 150-watt lamps and was considered to be very good or slightly bright when four 75-watt lamps were used. For conditions requiring operation of runway lights on steps 2 and 3, the brightness obtained by using four 75-watt lamps was preferred to that obtained with four 150-watt lamps.

The brightness of a section of the numeral at the center of the panel was measured with a brightness meter to determine what effect the use of different types and arrangements of lamps would have on the illumination of the marker. These results are given in table 3.

Table 3. Brightness at center of panel of Cecil Field runway distance marker

Type of Lamp	No. of Lamps	Brightness (Footlamberts) Runway Light Intensity Setting 1	2	3	4	5	110-120 Volts
75 watt, 120 volt	4	2.4	3.4	5.1	8.4	12.1	30
75 watt, 120 volt	6	2.4	3.7	5.8	10.9	15.4	67
100 watt, 120 volt	4	2.3	3.6	6.7	8.6	15.9	68
100 watt, 120 volt	6	1.33	3.2	4.7	10.7	13.1	90
150 watt, 120 volt	4	1.45	3.9	4.7	7.8	12.9	77
PH/211 photo-enlarger	4	2.8	4.8	5.1	11.9	13.8	59
PH/211 photo-enlarger	6	2.1	5.2	6.3	8.5	19.8	99
PH/212 photo-enlarger	4	1.19	4.6	5.8	11.2	21	80
PH/212 photo-enlarger	6	.026	.25	1.64	9.4	20	181

Visual observation indicated that the preferred lamp arrangement varied with the numeral on the panel. For numerals extending into the corners of the panel, six lamps provide more even brightness distribution over the numeral. For other numerals, the brightness distribution obtained by using only four lamps was satisfactory. When the lamps were spaced more than 15 inches apart, the uneven illumination was objectionable. For a standard lamp arrangement suitable for all numerals, the use of six lamps, three on each edge, with lamps located at the center and 8 inches from the top and bottom of the panel should be satisfactory (see figure 2). No lamps were located along the top or bottom of the marker, but for markers with double numerals, lamps at these positions may be required.

The results of NBS Reports 6337 and 6337 Supplementary[5/] were studied, in addition to the results reported above, to determine the best means of illuminating the markers. The observations for the many visibility conditions indicated that the light output of the illuminating lamps should vary by a ratio of approximately 20 to 1 as the runway lights are varied from 0.2 percent (step 1) to 100 percent (step 5) intensity. The desirable total light output of the lamps was found to be 200 to 400 lumens and 5000 lumens or more for runway light intensity steps 1 and 5 respectively. The 5000 lumens cannot be obtained from a single 200-watt series transformer by using 120-volt lamps. By using 75-volt lamps, light output of about 5000 lumens can be obtained.

The 75-volt lamp is not a standard lamp, and the change in light output between operation at step 1 and at step 5 would be too great. The 120-volt lamps provide adequate illumination except for very low visibility conditions. If a single transformer is used, the total rated wattage of the lamp load should be between 300 and 450 watts for best illumination of the marker at runway light intensity step 1. The light output at runway light intensity step 5 will be almost constant for rated lamp loads between 300 and 600 watts. Therefore, six 75-watt, 120-volt lamps will be satisfactory.

If a station finds the additional expense and power consumption are justified, it may double the illumination of the markers by using two series transformers for each marker, with three lamps on each transformer. When two transformers per marker are used, 200-watt, 120-volt lamps will be preferred, although 150-watt lamps may be satisfactory. Some improvement in brightness distribution can be obtained by using the data in NBS Reports 6337 and 6337 Supplementary to select the most suitable transformer.

After 14 months of exposure at this location, the Cecil Field marker required very little maintenance. Occasionally the top and panels needed cleaning because of birds fouling the marker. The retroreflective tape outlining the numerals had begun to curl along the edges and ends but had not required replacing at the end of the period. This marker would definitely reduce the routine maintenance required to less than that required for the present standard runway distance marker.

No attempts were made to evaluate the hazard potential of the mass of this marker. The elimination of the glare and shielding problems of the externally illuminated marker is an improvement in safety and operations.

5. CONCLUSIONS

The Cecil Field runway distance marker has a much greater effective range for nighttime operations than the standard externally illuminated marker. In daytime, the visual ranges are slightly less than the ranges of the standard marker, but the reduction in range is not significant. The legibility range of the Cecil Field marker is adequate for operations in daytime or nighttime conditions for visibilities of one-fourth mile or better. The marker provides information at reasonable distances in more restricted visibilities.

The brightness obtained from lamps operating at a constant intensity is not satisfactory for all visibility conditions. Satisfactory lighting of the marker for clear and for most restricted visibilities can be obtained by using 120-volt lamps with a total rated load of 300 to 600 watts and supplying these lamps through one 200-watt series/series transformer connected in the runway lighting

circuit. For very restricted visibility conditions, the use of two 200-watt series/series transformers, each supplying three 200-watt lamps, is desirable.

Six lamps are required to provide satisfactory illumination for each single-digit panel.

The internally illuminated markers present no special problems in glare or shielding. This is an improvement over the externally illuminated markers.

Very little maintenance is required for the Cecil Field marker and this maintenance is simple to perform.

6. RECOMMENDATIONS

It is recommended that:

1) The Cecil Field type marker be used instead of the existing externally illuminated runway distance marker as the standard for Navy installations.

2) Markers with single-digit panels be illuminated by using six 75-watt, 120-volt, multiple lamps, connected in parallel, and energized by a single 200-watt, 6.6-ampere secondary, series-series transformer connected to the runway lighting circuit.

3) The lamps for markers with single-digit panels be located as shown in figure 2 with a lamp 8 inches from the top, one 8 inches from the bottom, and at the midpoint for each side of the panel.

4) A study be made of the design and lamp placement for markers with double-digit panels.

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REFERENCES

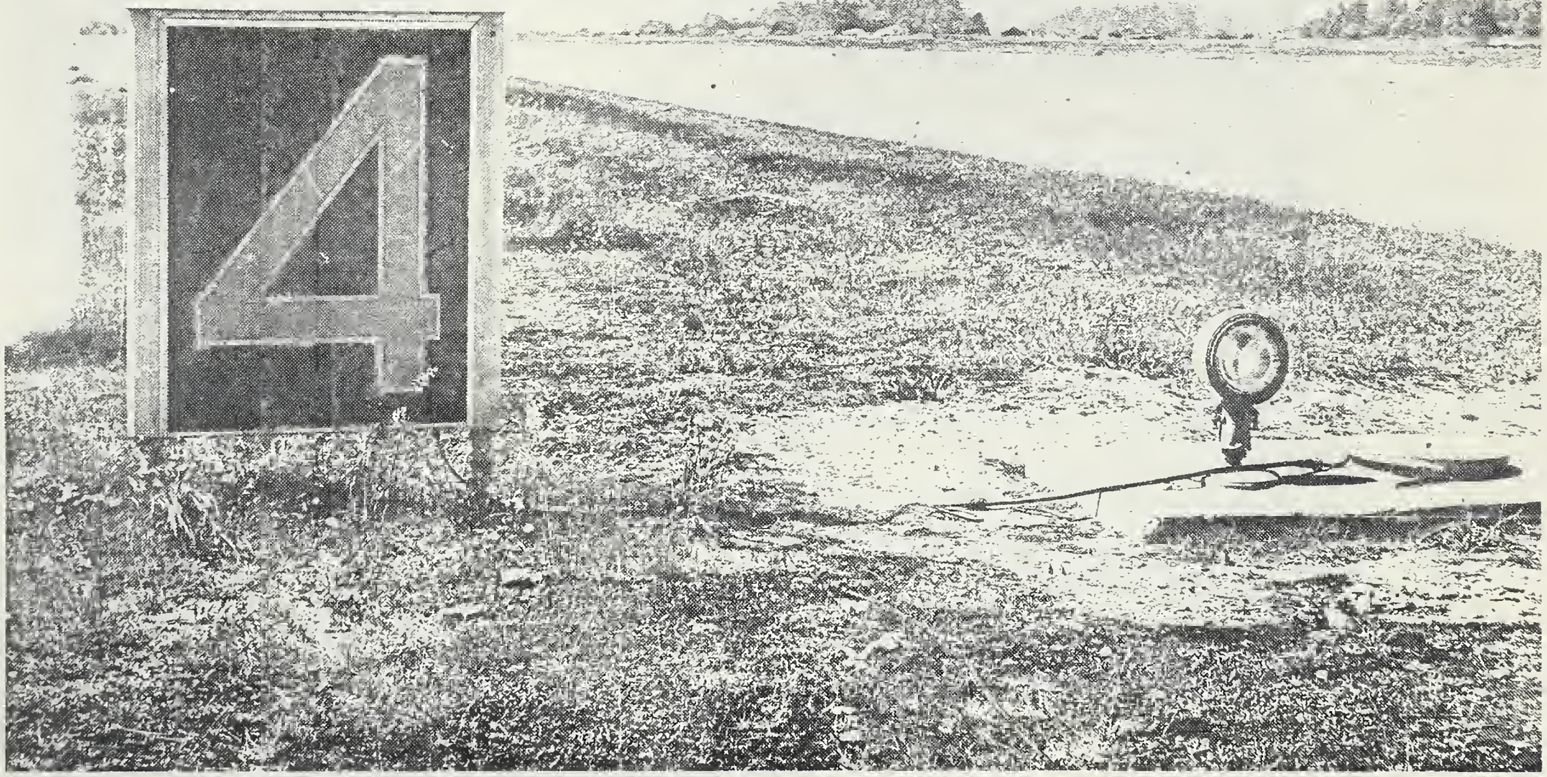
1. NAVAER 00-100-503 (Conf.), U. S. Naval Aeronautical Shore Facilities, Technical Planning Manual, Code 134 90.2 (1959)

2. NAVAER 00-100-505, U. S. Naval Aeronautical Shore Facilities Planning Standards, Drawing SE 134 90.2-1 (1959)

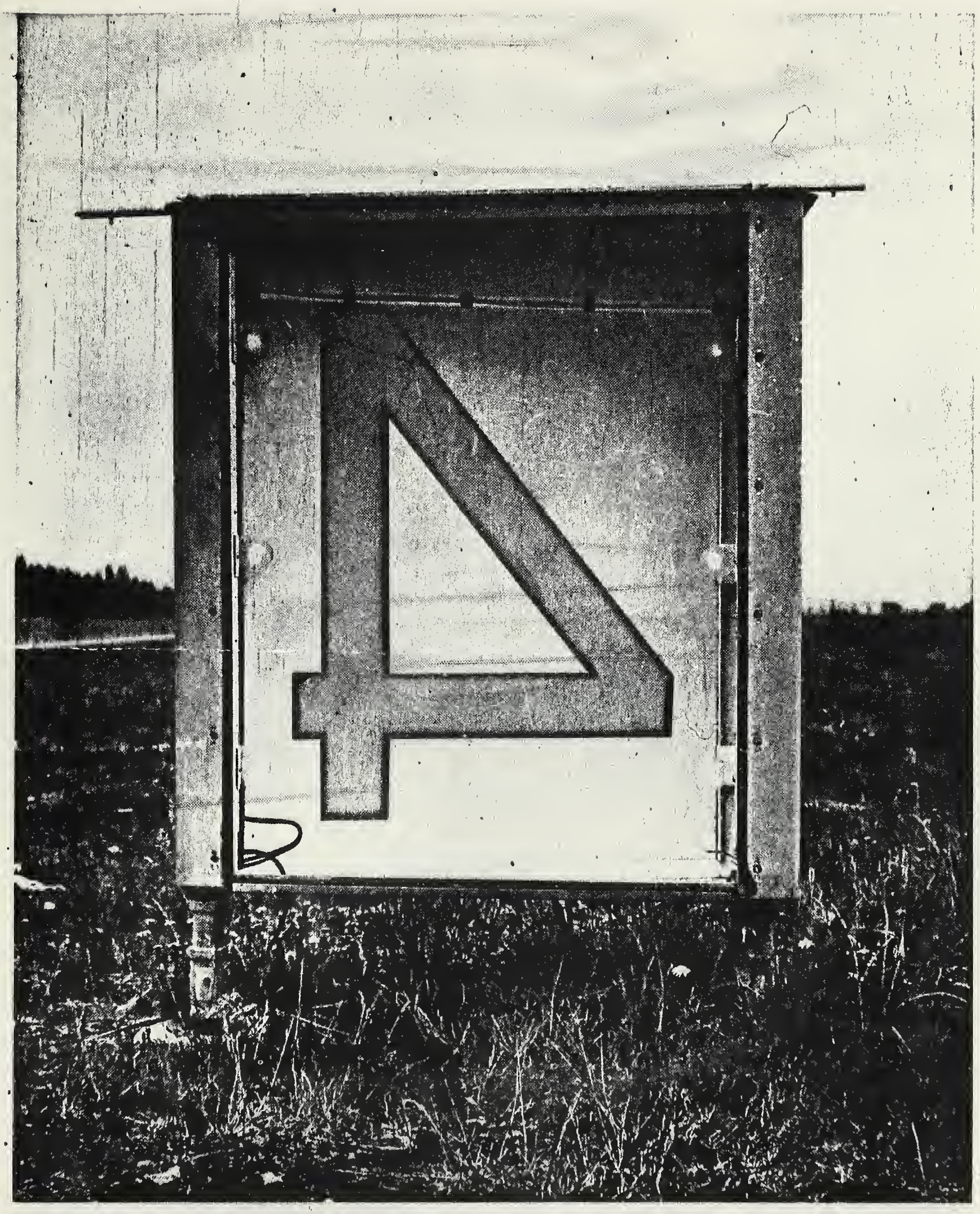
3. J. W. Simeroth, E. F. Bienz, M. R. Carrothers, NBS Report 5466, Field Tests of Runway Distance Markers (1957)

4. James E. Davis, NBS Report 6337, Output Characteristics of Three 200-watt Series-Series Transformers with Multiple Lamps as Loads (1959)

5. James E. Davis, NBS Report 6337 Supplementary, Output Characteristics of Series-Series Transformers with Multiple Lamps as Loads (1960)



TEST INSTALLATION OF CECIL FIELD TYPE RUNWAY DISTANCE MARKER



INTERIOR OF RUNWAY DISTANCE MARKER

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